Carnegie Lake Phase I Diagnostic / Feasibility Study

Conducted as part of the US Army Corp of Engineers, NY District's

Stony Brook – Millstone Watershed Flood Damage Reduction

And Ecosystem Restoration Feasibility Study

Revised October 2004

Goals of the presentation

- Present the findings of the hydrologic budget for Carnegie Lake.
- Present the findings of the pollutant budget for Carnegie Lake (phosphorus, nitrogen and suspended solids).
- Describe how the resulting data will be used toward the development of the Restoration Plan.

pH

Project Objectives

- Generate a site specific and detailed seasonal database of the lake and its watershed.
- Quantify the hydrologic and pollutant loads of the watershed.
- Develop a Restoration Plan for the lake that addresses both short-term and long-term concerns.

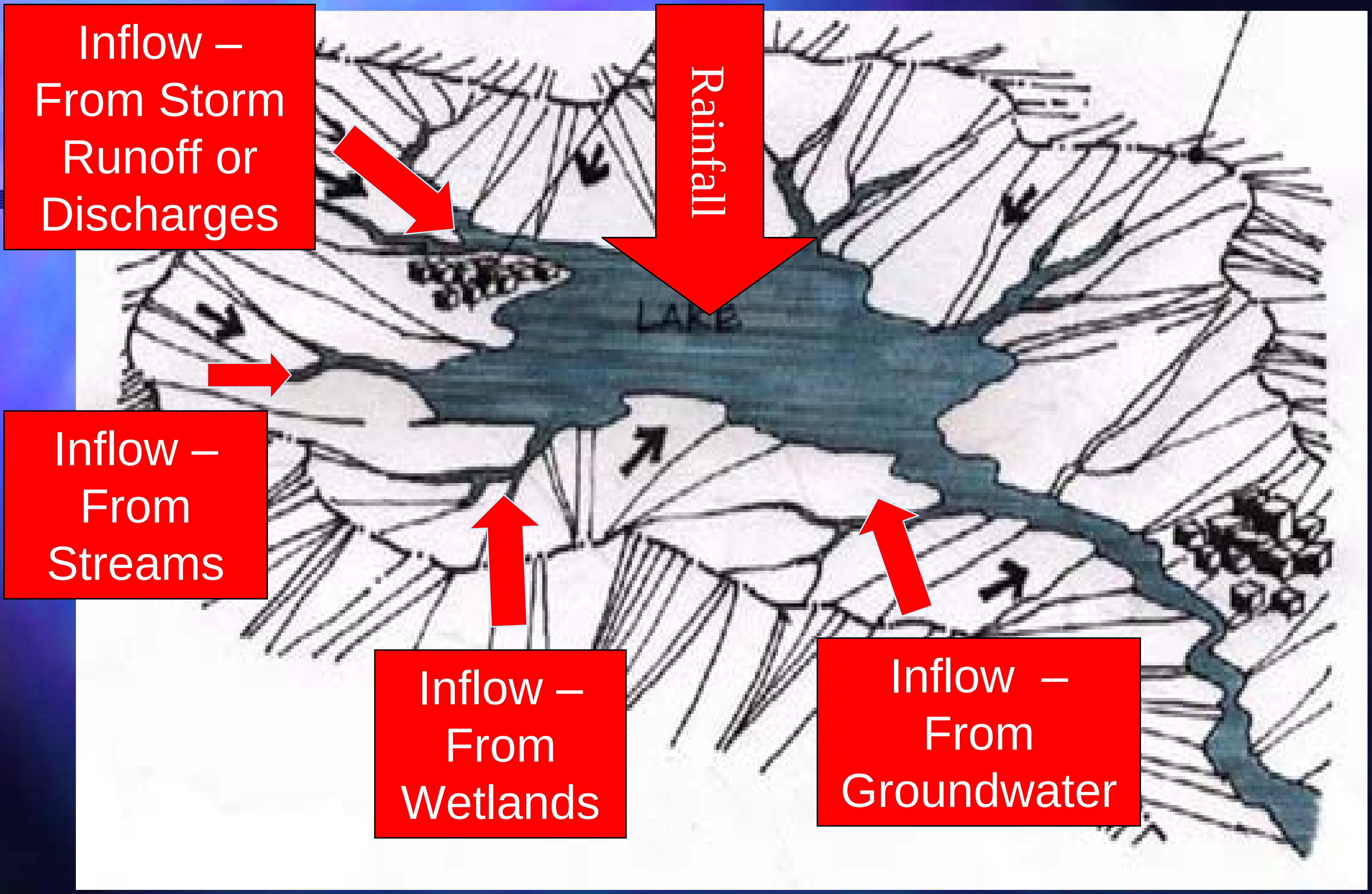
pH

Hydrologic Budget

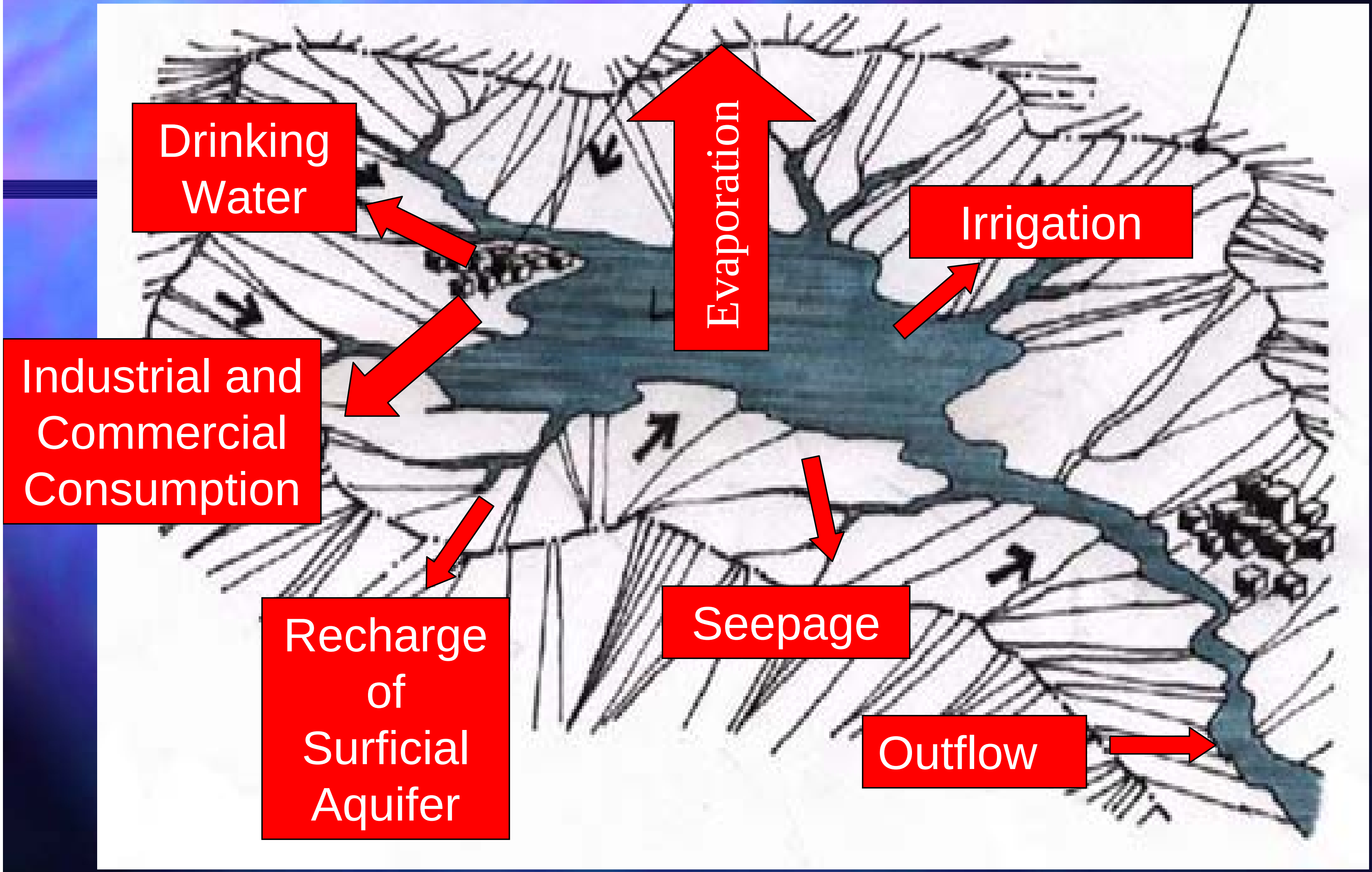
- It is the water balance or net difference between total inputs and total outputs.
- Inputs include tributary inflow, groundwater infiltration, surface runoff and precipitation directly over lake.
- Outputs include outflow, evaporation and seepage.
- Human activities also contribute to the input and output of a lake.

pH

pH


Inflow – From Storm Runoff or Discharges
Rainfall
LAKE
Inflow – From Streams
Inflow – From Wetlands
Inflow – From Groundwater

pH



Drinking Water
Evaporation
Irrigation
Industrial and Commercial Consumption
Recharge of Surficial Aquifer
Seepage
Outflow

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Outflow

- Outflow was quantified by using USGS streamflow data at Carnegie Lake dam (USGS 01401301).
- The 1986 through 1989 streamflow was used to calculate the annual outflow of Carnegie Lake, since data were consistently collected from this station at this time.
- The annual outflow for Carnegie Lake is 2.47×10^8 m^3.

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Bathymetric Survey

Parameter	Value
Lake Surface Area	259 acres (105 ha)
Mean Depth	3.4 ft (1.0 m)
Maximum Depth	7.1 ft (2.15 m)
Lake Volume	888 acre-ft (1.1 million cubic m)
Volume of Sediments	286,935 cubic yards
Mean Sed. Thickness	1.5 ft (0.45 m)
Max. Sed. Thickness	5.6 ft (1.7 m)

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Hydraulic Retention Time and Flushing Rate

- Using the lake's volume and annual outflow, the hydraulic retention time is 0.004 years or 1.62 days.
- The inverse of the hydraulic retention time is the flushing rate.
- The flushing rate for Carnegie Lake is 225 times per year or approximately 19 times per month.

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Precipitation

- The long-term annual rainfall for the Upper Millstone River watershed was used to quantify precipitation for Carnegie Lake.
- Annual rainfall was 45.88 inches with a evaporation rate of 54% (NJWSA, 2000).
- The net precipitation falling over the lake's surface is 0.56×10^6 m^3.

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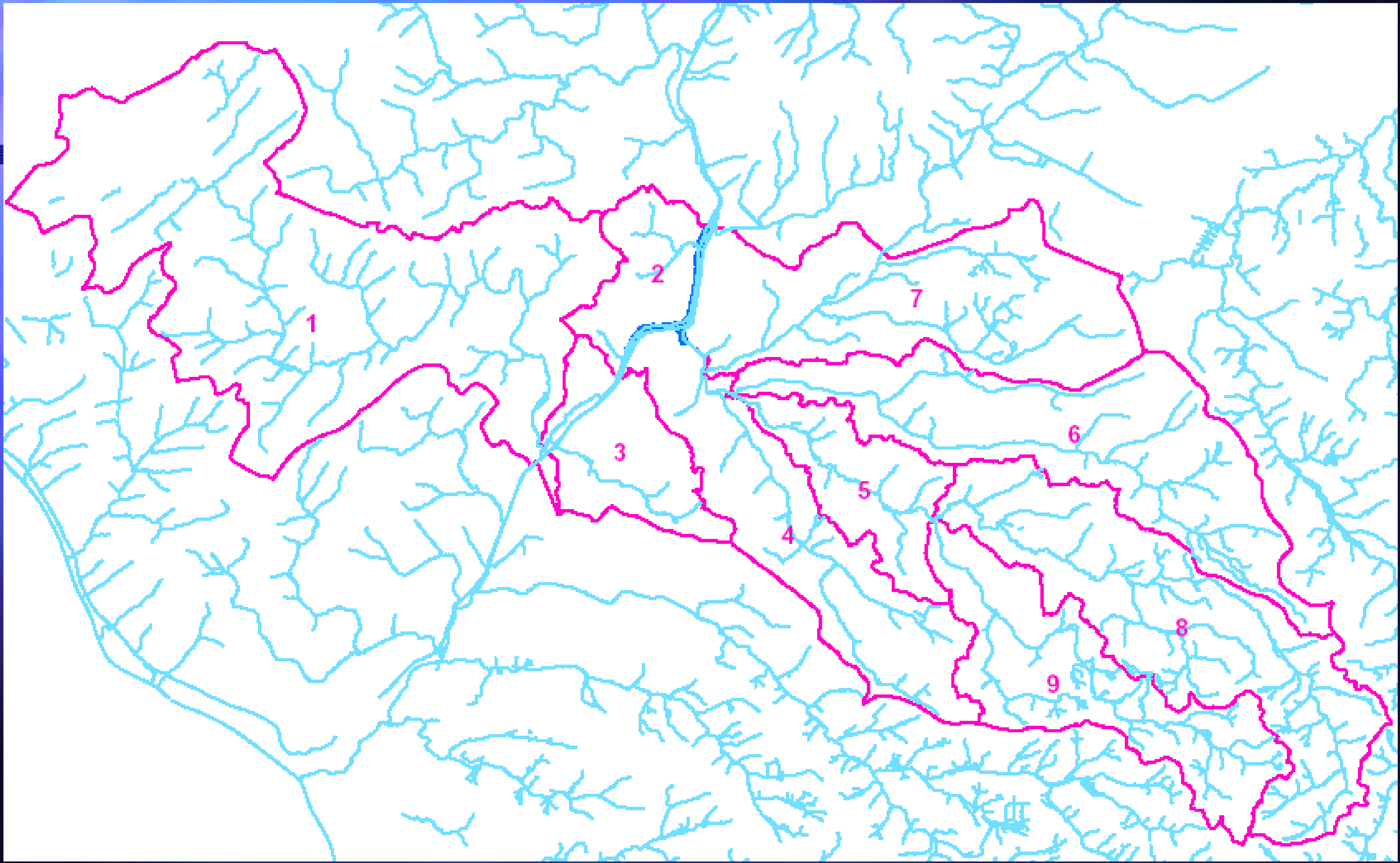
Surface Runoff

- A modified version of the Rational Method was used to calculate annual surface runoff for the Carnegie Lake watershed.
- The area of each land use / land type was multiplied by annual rainfall and a runoff coefficient (which is based on land type and soils).
- Surface runoff was calculated based on sub-watershed boundaries.

pH



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Surface Runoff

Sub-watershed	Cubic meters
Sub-watershed 1	35,365,756
Sub-watershed 2	6,656,548
Sub-watershed 3	Identified as draining into Canal
Sub-watershed 4	15,198,131
Sub-watershed 5	6,532,913
Sub-watershed 6	18,813,066
Sub-watershed 7	19,157,979
Sub-watershed 8	15,599,512
Sub-watershed 9	12,356,520
Total	**129,680,425**

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Groundwater

- Typically, the most difficult portion of the hydrologic budget to quantify.
- Since some detailed outflow data were available and large fluctuations in water level were not observed, groundwater was calculated by subtracting precipitation and surface runoff from the outflow load.

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Carnegie Lake Hydrologic Budget

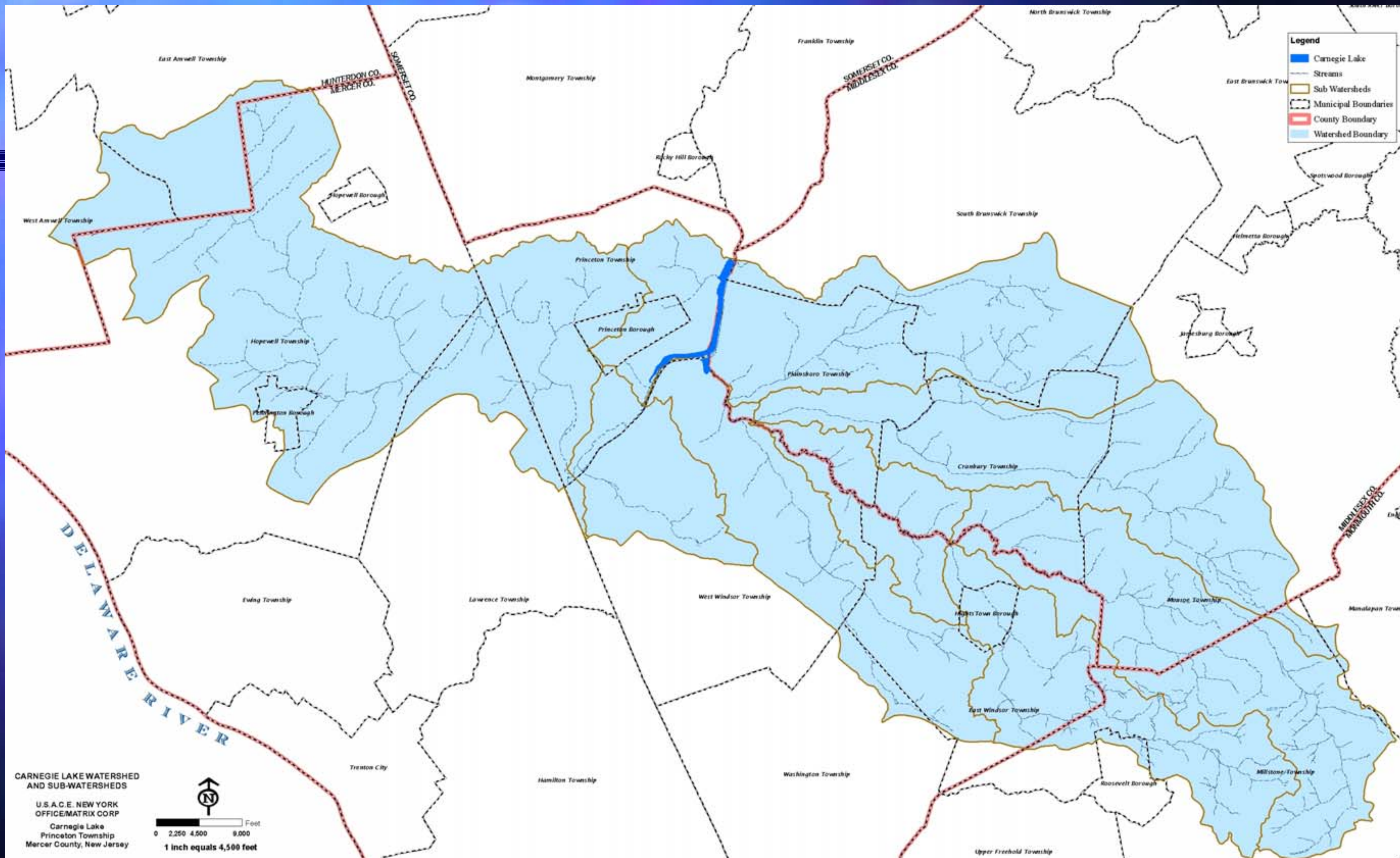
Hydrologic Source	Cubic meters	Percent
Net precipitation	561,886	0.2
Surface runoff	129,680,425	52.6
Groundwater	109,856,948	47.2
Total	**246,774,647**	**100.0**

pH

Pollutant Budget

- For the sake of this study, the term pollutant refers to the nutrients nitrogen (TN) and phosphorus (TP) and total suspended solids (TSS).
- These pollutants were quantified on an annual basis. Surface runoff pollutant loads were divided based on sub-watershed and municipal boundaries.

pH



Legend
Carnegie Lake
Streams
Sub Watersheds
Municipal Boundaries
County Boundary
Watershed Boundary
HUNTERDON CO.
MERCER CO.
SOMERSET CO.
MIDDLESEX CO.
MONMOUTH CO.
DELAWARE RIVER
CARNEGIE LAKE WATERSHED
AND SUB-WATERSHEDS
U.S.A.C.E. NEW YORK
OFFICE/MATRIX CORP
Carnegie Lake
Princeton Township
Mercer County, New Jersey
0 2,250 4,500 9,000
Feet
1 inch equals 4,500 feet

pH

Pollutant Budget

- Point sources of pollution
- Surface runoff (non-point source pollution)
- Atmospheric sources (precipitation / dryfall)
- Groundwater / baseflow
- Internal loading from the sediments

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Point Sources

- Known sources of pollution from permitted pipes or other structures (NJPDES).
- The original database had 63 NJPDES numbers for the Carnegie Lake watershed.
- Five municipal dischargers were identified as contributing large amounts of TN, TP and/or TSS.

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Point Sources in kg (Mean of 2002 and 2003 values)

Source	TN*	TP	TSS
Educational Testing Service	9	6	144
Princeton Meadows	29,183	1,176	20,165
Stony Brook RSA - 2	19	1,514	511
East Windsor	3,618	1,586	7,116
Highstown	15,756	226	2,581
Total	**48,585**	**4,508**	**30,517**

*** Point Source TN is actually ammonia-N and sometimes nitrate-N**

pH

Non-Point Source Pollution

- Surface runoff and stormwater, transporting fertilizers, goose and pet feces to the lake.
- Streambank and soil erosion also transports phosphorus and solids.
- The Unit Aeral Loading (UAL) method was used to quantify the NPS pollutant loads.
- Selected loading coefficients were multiplied by the identified land type.

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NPS Pollution by Sub-watershed

Sub-watershed	TN	TP	TSS
Sub-watershed 1	59,018	5,175	7,701,727
Sub-watershed 2	7,708	1,244	1,103,141
Sub-watershed 3	-----	-----	-----
Sub-watershed 4	21,932	2,423	3,381,533
Sub-watershed 5	14,320	1,052	1,794,574
Sub-watershed 6	33,137	3,071	4,850,481
Sub-watershed 7	33,523	3,245	5,552,410
Sub-watershed 8	36,117	2,339	4,067,984
Sub-watershed 9	21,306	2,047	2,749,449
Total	**227,061**	**20,596**	**31,201,299**

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NPS Pollution by municipality

- Eighteen municipalities are located within the Carnegie Lake watershed.
- For each pollutant, five to six municipalities accounted for over half of the total NPS pollutant loads.
- Millstone Township had the largest annual TN load, while Hopewell Township had the largest annual TP and TSS loads.

Other Pollutant Sources

- Atmospheric sources of TN and TP were calculated by using loading coefficients for rainfall and dryfall.
- Temperature and dissolved oxygen vertical profiles were used to identify oxic (with oxygen) and anoxic (without oxygen) zones within Carnegie Lake. Coefficients were then used to calculate the internal TP load.

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Other Pollutant Sources

- The groundwater / baseflow contribution to the annual pollutant loads was calculated by multiplying the annual hydrologic load for groundwater by the mean baseflow pollutant concentrations.

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Annual TN Budget for Carnegie Lake

Source	TN (kg)	Percent
Point Sources	48,585	9.7
NPS Sources	227,061	45.1
Atmospheric	17,480	3.5
Internal Loading	-----	-----
Groundwater	209,827	41.7
Total	**502,952**	**100.0**

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Annual TP Budget for Carnegie Lake

Source	TP (kg)	Percent
Point Sources	4,508	13.2
NPS Sources	20,596	60.4
Atmospheric	89	0.3
Internal Loading	109	0.3
Groundwater	8,789	25.8
Total	**34,091**	**100.0**

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Annual TSS Budget for Carnegie Lake

Source	TSS (kg)	Percent
Point Sources	30,517	0.1
NPS Sources	31,201,299	97.5
Atmospheric	-----	-----
Internal Loading	-----	-----
Groundwater	768,999	2.4
Total	**33,494,169**	**100.0**

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Conclusions – Hydrologic Budget

- The high flushing rate of Carnegie Lake aids in minimizing the development of large and frequent algal blooms.
- The unique hydrologic properties of Carnegie Lake makes it difficult to model, based on some of the more common water quality models.

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Conclusions – Pollutant Budget

- Non-point sources are the largest source of phosphorus for Carnegie Lake.
- Sub-watershed 1 (a large portion of the Stony Brook watershed) is the largest source of NPS pollution.
- Point sources account for less than 14% of the annual phosphorus load.

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Conclusions – Pollutant Budget

- Hopewell Township was the largest municipal source of the NPS pollutants TP and TSS.
- It appears that developed land is surpassing agricultural land as the dominant source of NPS pollution, particularly TP and TSS.

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The Next Step……

- Conduct field visit in early to mid-October to aid in prioritizing potential sites for restoration.
- Utilize all of the information to develop a Restoration Plan for Carnegie Lake.

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Some possible in-lake strategies

- Selective dredging of specific areas of the lake. Some potential locations include the southern most end of the lake and adjacent to the public boat launch.
- Some pro-active fishery management.
- Potential installation of near shore circulators.
- Address shoreline invasive species.

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Some possible watershed-based strategies

- Focus more on addressing NPS originating from developed land, especially in those municipalities that contribute the largest portions of TP and TSS to the lake.

pH

Some possible watershed-based strategies

- The implementation of structural BMPs to reduce existing and future pollutant loads related to residential / commercial runoff.
- Such potential structural BMPs include grassed swales, retention ponds, infiltration basins, porous pavement, nutrient / sedimentation chambers.

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Some possible watershed-based strategies

- Streambank stabilization will be another important means of protecting Carnegie Lake, especially relative to TSS loading.
- Managing the “Millstone wetland” more as a wetland and less as open waters.
- Public education needs to focus on the management of Carnegie Lake and its associated natural resources relative to invasive species.

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Thank You

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